Chapter 5
Slurry Walls

5-1. General

The design and function of slurry walls and specific uses of cement/bentonite walls are discussed in the chapter's first section. The second portion of the chapter is a hazard analysis with controls and control points listed.

5-2. Technology Description

a. Design and Function of Slurry Walls.

A slurry wall is an in-ground physical containment device designed to isolate contaminant source zones and groundwater plumes from the surrounding environment. Contaminated soil, wastes, and groundwater can be physically isolated within surrounding low-permeability barriers by constructing a vertical trench excavated down to and keyed into a deeper confining layer, such as a low-permeability clay or shale, and filling the trench with a slurry. Slurry walls usually consist of a soil, bentonite, or cement mixture. The slurry mix hydraulically shores the trench to prevent collapse during installation and forms a permeation barrier to prevent the escape of contaminants from the contained area. As the excavation continues, additional slurry is added, and the process continues until the depth and length needed are completed. A schematic diagram of a slurry wall configuration is presented in Figure 5-1.

Slurry walls are commonly used subsurface barriers because they are a relatively inexpensive means of reducing groundwater flow in unconsolidated earth material and are also useful for sites where present technologies can not effectively or economically treat contaminant sources. Cement and bentonite construction of a wall can adsorb and retard the escape of heavy metals and larger organic molecules but can not completely stop water movement. Consequently, slurry walls are either "stop-gap" measures or are typically accompanied (as illustrated in Figure 5-1) by pump-and-treat systems. Often the enclosed area is capped or covered to prevent additional infiltration of water behind the wall.

Slurry walls are also used to direct or funnel the flow of groundwater to pump-and-treat well arrays or in-situ treatment areas, such as a reactive wall or biosparging array. Soil/bentonite walls have been used for decades for groundwater control in conjunction with large dam projects. However, the ability of these walls to withstand long-term permeation by many contaminants is unknown. Evidence indicates that soil/bentonite backfills are not able to withstand attack by strong acids and bases, strong salt solutions, and some organic chemicals.

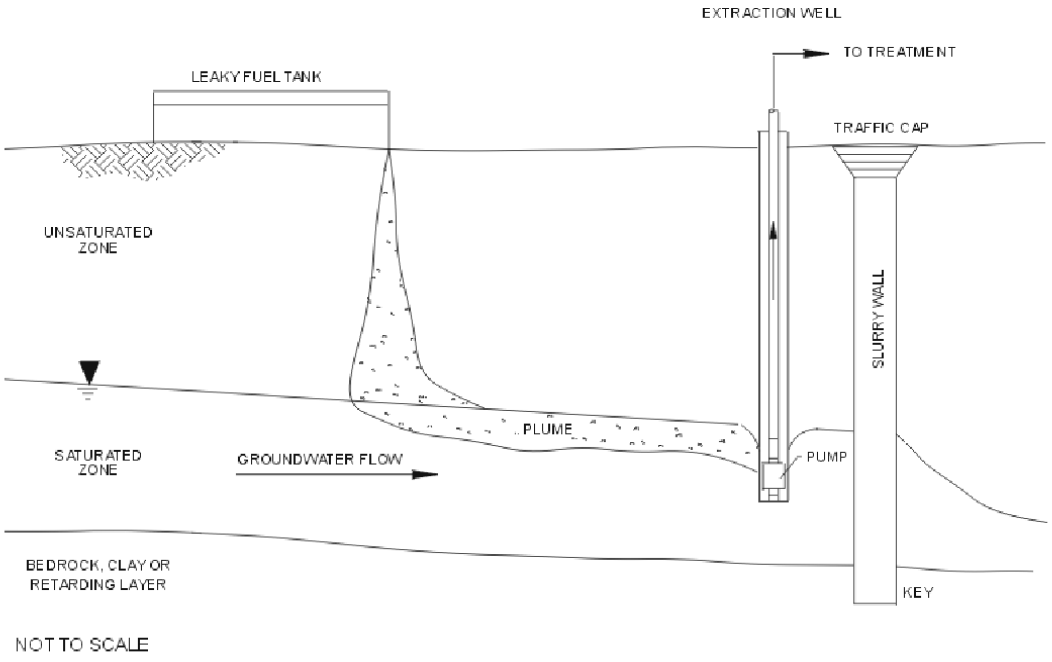

FIGURE 5-1. SLURRY WALLS

b. Cement/Bentonite Walls.

Cement/bentonite walls are more expensive than soil/bentonite walls and are generally used where: (1) there is no room to mix and place soil/bentonite backfills; (2) increased mechanical strength is required; or (3) extreme topography conditions (slopes) make it impractical to grade a site level. Cement/bentonite slurry walls are limited in their use by their higher permeability and their narrow range of chemical compatibilities (more susceptible to attack by sulfates, strong acids or acid bases, and other highly ionic substances).

5-3. Hazard Analysis

The principal unique hazards associated with the slurry walls, methods for control, and control points are described below.

a. Physical Hazards.

(1) *Equipment Hazards*.
Description. During soil excavation, workers may be seriously injured or killed by heavy equipment such as front-end loaders and backhoes. This equipment may also cause a noise hazard to workers.

Control. Controls for equipment hazards include:
- Use heavy equipment with a backup alarm to alert workers.

- Approach operating equipment from the front and within view of the operator, preferably making eye contact.
- Wear hearing protection around operating equipment.
- Train workers in the operational hazards and safety features associated with the heavy equipment.

CONTROL POINT: Construction

(2) *Utility or Underground Structure Hazards*.
Description. Fire, electrocution, or explosion hazards may exist during installation of the slurry wall if a backhoe ruptures an underground utility, such as sewers, pipelines, or electrical or gas lines. Abrupt equipment stoppages attributable to contact with underground structures, such as foundations, may cause a dangerous condition leading to equipment-related accidents.

Control. Controls for utility and underground structure hazards include:
- Train the personnel in the hazards of excavating in the vicinity of underground or overhead utilities.
- Train the operators in emergency procedures in case of a catastrophic event, in life saving first aid procedures for electrocutions, burns, and extinguishing flames, extracting, extinguishing and stabilizing victims, and in emergency excavation isolation procedures. If workers are required to enter the excavation, rigorously train in protective shoring measures (see 29CFR 1926.650 - .652) and in confined space requirements (see 29CFR 1926.21).
- Identify the location of all below- and above-ground utilities prior to excavation by contacting local utilities and public works personnel. When there is any doubt or uncertainty, perform a utility survey, probe with a metal rod, or hand excavate prior to excavation to determine the exact location of utilities. Once utilities are located, careful excavation by backhoe may be allowed.
- Post an observer to the side to supervise when raising a backhoe or other equipment.

CONTROL POINT: Design, Construction

(3) *Trench Hazards*.
Description. Open excavations may pose fall hazards to personnel working near the trench. The trench wall may collapse or the worker may fall into the trench while measuring trench depth or collecting samples.

Control. Controls for trench hazards include:
- Inspect the excavation each day to ensure the stability of the walls.
- Limit worker activities near the excavation and only approach wearing fall protection, such as a safety harness or attached lanyard.
- Require all workers near or adjacent to the trench to wear life vests in the event that a worker falls into the slurry as the wall is being poured.
- Equip all personnel crossings with handrails.

- Train workers in unique hazards associated with working in trenches and in the controls required, such as shoring prior to entry.

CONTROL POINT: Construction, Operations

(4) *Steam Pressure Washing*.
Description. Steam pressure washing of equipment may expose workers to thermal, burn or injection hazards, eye hazards from flying projectiles dislodged during pressure washing, slip hazards from wet surfaces, and noise hazards.

Control. Controls for steam pressure washing include:
- Use insulated gloves (e.g., silica fabric gloves) and keep all body parts away from the ejection point of the steam pressure discharge nozzle.
- Wear safety goggles and hearing protection.
- Equip the washer with deadman or kill switch if not provided by the manufacturer.
- Wear slip-resistant boots.
- Drain water away from the decontamination operation into a tank or pit.
- Drain walking surfaces and keep free of standing liquids or mud.

CONTROL POINT: Construction, Operations

(5) *UV Radiation*.
Description. During site activities, workers may be exposed to direct and indirect sunlight and corresponding UV radiation. Even short-term exposure to sunlight can cause burns and dermal damage. Hot and humid conditions may also result in heat stress, which can manifest itself as heat exhaustion and heat stroke.

Control. Controls for UV radiation include:
- Minimize direct sun exposure by wearing sun hats, long-sleeved shirts, full-length pants, and by applying UV barrier sunscreen. Loose clothing and sun hats should not be worn around moving parts or close to operating equipment that may snag the worker and draw him or her into a danger zone. All UV skin barrier creams should be pre-approved.
- Shade work and break areas if possible.
- Minimize exposure to heat stress by taking frequent breaks, drinking adequate fluids, and working during the early morning and late afternoon hours.
- Use the Buddy System.
- Monitor for heat stress using the physiological or Wet Bulb Globe Temperature (WBGT) Index protocol provided in the most recent publication of the American Conference of Governmental Industrial Hygienists (ACGIH) "TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices."

CONTROL POINT: Construction, Operations

(6) *Electrocution Hazards*.
Description. Workers may be exposed to electrocution hazards when working around electrical utilities such as overhead power lines.

Control. Controls for electrocution hazards include:
- Verify the location of overhead power lines, either existing or proposed, in the pre-design phase.
- Keep all lifting equipment, such as cranes, forklifts, and drilling rigs at least 10 feet from the power line according to Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1926.550 and EM 385-1-1, Section 11.E.

CONTROL POINT: Design, Construction, Operations

(7) *Heavy Equipment Hazards*.
Description. The heavy equipment (small and large) used for site operations may roll over on steep slopes or unstable ground, seriously injuring the operator. Trucks loaded with backfill can back up too far and become stuck in the trench.

Control. Controls for heavy equipment hazards include:
- Design the angle of the slope to minimize the potential for roll-over.
- Maintain safe operating conditions for equipment during construction (construction contractor).
- Provide workers and spotters in the vicinity of operating heavy equipment with fluorescent orange or lime green traffic vests.
- Use heavy equipment with roll-over protective devices (ROPS) and do not operate on steep slopes or unstable ground.
- Train workers in the potential operational hazards and safety features of the heavy equipment.

CONTROL POINT: Design, Construction, Operations

(8) *Traffic Hazards*.
Description. During field activities, equipment and workers may come close to traffic. Also, drilling rigs and other equipment may need to cross or use public roads. The general public may be exposed to traffic hazards and the potential for accidents during loading and transporting soil.

Control. Controls for traffic hazards include:
- Post warning signs according to the criteria of the "Department of Transportation Manual on Uniform Traffic Devices for Streets and Highways."
- Provide traffic guides with fluorescent orange or lime green safety vests.
- Develop a traffic management plan before remediation activities begin to help prevent accidents involving site trucks and automobiles. EM 385-1-1, Section 21.I.10, provides plan details.

CONTROL POINT: Design, Construction, Operations

(9) *Respirable Quartz Hazard.*
Description. Depending on soil types, exposure to respirable quartz may be a hazard. Consult geology staff to confirm the presence of a respirable quartz hazard (e.g., to determine if soil types are likely to be rich in respirable quartz). As an aid in determining respirable quartz exposure potential, sample and analyze site soils for fines content by ASTM D422 (R2002): "Standard Test Method for Particle Size Analysis of Soils" followed by analysis of the fines by X-ray diffraction to determine crystalline silica quartz content.

Control. Controls for respirable quartz include:
- Wet soil periodically with water to minimize worker exposure. Wetting of soil may require additional controls to deal with resulting water, ice, mud, etc. Consult 29 CFR 1910.1000, Table Z-3, to calculate acceptable respirable dust concentrations based on percent silica in the quartz.
- Use respiratory protection, such as an air purifying respirator equipped with N, R or P100 particulate air filters.
- Train workers in the potential inhalation hazards of crystalline silica dust exposures.

CONTROL POINT: Design, Construction, Operations, Maintenance

(10) *Emergency Wash Equipment.*
Description. Emergency shower/eye wash equipment required per 29 CFR 1910.151 is not always provided with adequate floor drains, thereby creating potential electrical hazards and walking surface hazards during required testing and use.

Control. A control for emergency wash equipment includes:
- See American National Standards Institute ANSI Z 358.1 – 1998: "Emergency Eyewash and Shower Equipment" for design requirements.
- Equip showers/eye wash equipment with accompanying functional drains to isolate and collect the shower/eye washwater from unprotected electrical equipment and walking surfaces that, when wet, create slipping and electrical hazards.

(11) *Design Field Activities.*
Description. Design field activities associated with subsequent construction may include surveying, biological surveys, soil gas surveys, geophysical surveys, trenching, drilling, stockpiling, contaminated groundwater sampling, and

other activities. Each of these field activities may expose the survey personnel to physical, chemical, radiological, and biological hazards.

Control. Controls for hazards resulting from design field activities include:

- Prepare an activity hazard analysis for design field survey activities. EM 385-1-1, Section 1, provides guidance on developing an activity hazard analysis.
- Train workers in hazards identified.

CONTROL POINT: Design

b. Chemical Hazards

Slurry/Contamination Hazards.
Description. During excavation/mixing/installation operations, workers may be exposed to inhalation/ingestion/dermal hazards from caustic irritants such as portland cement, airborne dusts, volatile organic compounds (VOCs), metals, or free silica from soil/bentonite mixtures and waste materials. Eye exposure may occur, resulting in scratching and scarring of eyes.

Control. Controls for contamination hazards include:

- Reduce airborne dusts by periodically applying water, amended water, or emission-suppressing foams to the active excavation and mixing areas. The addition of foam to control vapors may also create a slip and fall hazard. Workers should not walk on areas to which foam has been applied.
- Minimize the amount of soil agitation during mixing operations.
- Erect wind screens and portable surface covers.
- Use the proper types of PPE: an air-purifying respirator equipped with approved N, R or P100 or N, R or P95 particulate air filters, OV cartridges for vapors, or combination filter/cartridges for dual protection, and eye protection.
- Use experienced workers, frequent health and safety meetings, decontamination stations, and other standard procedures.

CONTROL POINT: Design, Construction, Operations

c. Radiological Hazards.

Radioactive Material.
Description. Radiological materials may have been buried or naturally occurring radioactive material (NORM) may be present in the excavated soils, sludge, and groundwater. Some radioactive materials may present an external hazard. All radioactive materials may present an internal exposure hazard through inhalation or ingestion. Note that this may be a rare hazard to encounter using this remediation technology.

Control. Controls for radioactive materials include:

- Test excavated soil, sludge, or groundwater to determine if radioactive materials are present.
- Consult a qualified health physicist if any radioactive material above background levels is found. Consultation should result in determination of exposure potential, any necessary engineered controls, or PPE required.

CONTROL POINT: Design, Construction, Operations

d. Biological Hazards.

(1) *Biological Contaminants.*
Description. At those sites involving medical wastes or sewage sludge, microorganisms in the soil may cause exposure hazards during the soil mixing and waste stabilization activities. Workers may be exposed to inhalation/ingestion/dermal contact with pathogens, such as *Coccidioides sp.*, *Histoplasma sp.*, and *Mycobacterium sp.* if contaminated dusts become airborne.

Control. Controls for biological contaminants include:
- Reduce generation of airborne microbe-contaminated dust with the periodic application of water, amended water, or emission-suppressing foams to the active excavation and mixing areas. The addition of foam to control vapors may also create a slip and fall hazard. Workers should not walk on areas where foam has been applied.
- Minimize the amount of soil agitation during mixing operations.
- Erect windscreens and use portable surface covers.
- Use proper types of PPE such as an air-purifying respirator with N, R or P100 or N, R or P95 particulate air filters approved for microbial inhalation hazards.
- Use experienced workers, repeated health and safety meetings, decontamination stations, and other standard procedures.

CONTROL POINT: Design, Operations

(2) *Pests*.
Description. Workers may be exposed to a wide array of biological hazards, including snakes, bees, wasps, ticks, hornets, and rodents, during any phase of remediation. The symptoms of exposure vary from mild irritation to anaphylactic shock and death. Deer ticks may cause Lyme disease. Rodents can transmit Hanta virus. Mosquitoes can transmit the West Nile Virus.

Control. Controls for pests include:
- Perform periodic inspections of the site to identify stinging insect nests and to check for snakes and rodents.
- Use professional exterminating companies if necessary.
- Use tick and insect repellents containing N,N-diethyl-m-toluamide (DEET) 25% as an active ingredient for exposure control. Clothing may be treated

with permethrin clothing repellent BEFORE donning, for added protection. Workers should check their skin and clothing for ticks periodically throughout the workday.

CONTROL POINT: Construction, Operations, Maintenance